



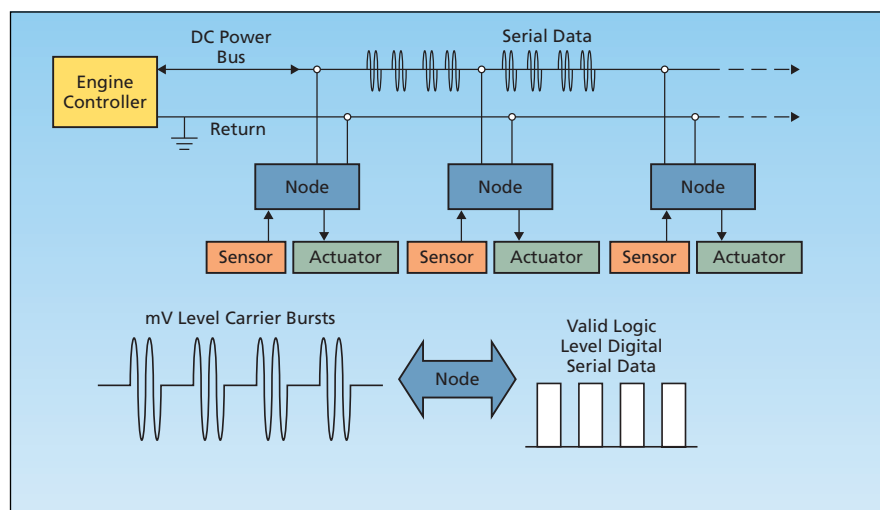
Circuit and Method for Communication Over DC Power Line

New technique usable in harsh, high-heat environments, allows for networking and smart vehicle operation with no additional wiring beyond power.

John H. Glenn Research Center, Cleveland, Ohio

A circuit and method for transmitting and receiving on-off-keyed (OOK) signals with fractional signal-to-noise ratios uses available high-temperature silicon-on-insulator (SOI) components to move computational, sensing, and actuation abilities closer to high-temperature or high-ionizing radiation environments such as vehicle engine compartments, deep-hole drilling environments, industrial control and monitoring of processes like smelting, and operations near nuclear reactors and in space. This device allows for the networking of multiple, like nodes to each other and to a central processor. It can do this with nothing more than the already *in-situ* power wiring of the system. The device's microprocessor allows it to make intelligent decisions within the vehicle operational loop and to effect control outputs to its associated actuators. The figure illustrates how each node converts digital serial data to OOK 18-kHz in transmit mode and vice-versa in receive mode; though operations at lower frequencies or up to a megahertz are within reason using this method and these parts.

This innovation's technique modulates a DC power bus with millivolt-level signals through a MOSFET (metal oxide semiconductor field effect transistor) and resistor by OOK. It receives and demodulates this signal from the DC power bus through capacitive coupling at high temperature and in high ionizing radiation environments. The demodulation of the OOK signal is accomplished by using an asynchronous quadrature detection technique realized by a quasi-discrete Fourier transform through use of the quadrature components (0° and 90° phases) of the carrier frequency as generated by the microcontroller and as a function of the selected crystal frequency driving its oscillator. The detected signal is rectified using an absolute-value circuit containing no diodes (diodes being non-operational at high temperatures), and only operational amplifiers.



In **Transmitting and Receiving OOK Signals**, each node converts digital serial data to OOK 18-kHz in transmit mode, and vice-versa in receive mode.

The absolute values of the two phases of the received signal are then summed and hard limited (digitized) by comparing them to a reference level and are then input into a microprocessor as a serial bit stream. The quasi-discrete Fourier transform is performed in high-temperature components (operational amplifiers, analog switches, resistors, and capacitors). The demodulated signal is a serial data stream that is input to the UART (universal asynchronous receiver transmitter) receiver pin of the microprocessor. The OOK of the carrier frequency uses the output of the UART pin as an enabling signal that drives the gate of the MOSFET. Logic low bits enable the carrier frequency (realized by using the 0° phase signal from the microcontroller, though either phase may be used) to be DC-coupled to the power supply bus through a current-limiting resistor mounted between the MOSFET drain and the supply rail. The presence of logic lows on the power supply rail is realized by carrier bursts while logic highs are realized by the absence of bursts.

The local power for the circuit is derived from a 5-volt regulator with the DC power supply rail as its input. The data imposed

upon the supply rail does not substantially present itself upon the local power rail of the circuit because its lower excursions are above the dropout voltage of the regulator, and are also within the regulator's power supply rejection specifications. By needing only the power bus for both power and data, this device represents a decrease in added weight to an engine system. Also, moving processing power closer to actuators and sensors makes distributed control possible by lessening the burden on a central processing element.

This device is configured from commercially available components. The commercial amplifier and analog switch used in this device also have been shown to have high ionizing radiation hardness. This technique is portable to any component grade for applications in more benign environments.

This work was done by Michael J. Krawski and Norman F. Prokop of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18207-1.